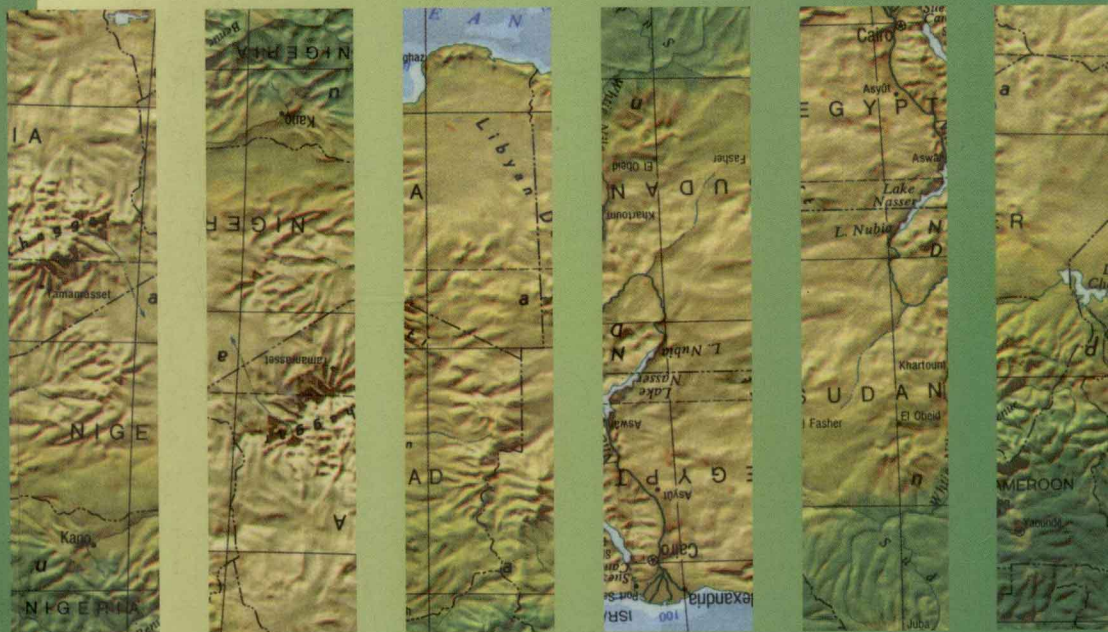


Global Environmental Risk



Edited by
Jeanne X. Kasperson and Roger E. Kasperson

Global environmental risk

Edited by Jeanne X. Kasperson and Roger Kasperson



**United Nations
University Press**

TOKYO • NEW YORK • PARIS

EARTHSCAN

Earthscan Publications Ltd
London • Sterling, VA

© The United Nations University, 2001

All rights reserved

First published in 2001 by the United Nations University Press and Earthscan Publications Ltd

ISBN 92-808-1027-8 (UNUP paperback; not for sale in Europe and the Commonwealth, excluding Canada)

1 85383 801 2 (Earthscan paperback; not for sale in the USA and Canada)

1 85383 800 4 (Earthscan hardback)

The views expressed in this publication are those of the authors and do not necessarily reflect the views of the United Nations University.

United Nations University Press

The United Nations University, 53-70, Jingumae 5-chome,
Shibuya-ku, Tokyo, 150-8925, Japan

Tel: +81-3-3499-2811 Fax: +81-3-3406-7345

E-mail: mbox@hq.unu.edu

<http://www.unu.edu>

United Nations University Office in North America

2 United Nations Plaza, Room DC2-1462-70, New York, NY 10017, USA

Tel: +1-212-963-6387 Fax: +1-212-371-9454

E-mail: unuona@igc.apc.org

United Nations University Press is the publishing division of the United Nations University.

Earthscan Publications Ltd

120 Pentonville Road, London, N1 9JN, UK

Tel: +44 (0)20 7278 0433 Fax: +44 (0)20 7278 1142

<http://www.earthscan.co.uk>

Cover design by Joyce C. Weston

Printed in the United Kingdom

Library of Congress Cataloging-in-Publication Data

Global environmental risk / Edited by Jeanne X. Kasperson and Roger Kasperson.

p. cm.

Includes bibliographical references and index.

ISBN 92-808-1027-8

1. Environmental risk assessment. 2. Global environmental change. I.

Kasperson, Jeanne X. II. Kasperson, Roger E.

GE145.G57 2001

333.7/14—dc21

2001000693

Global environmental risk

Note from the editors

The wellspring for this volume is an international workshop, "Understanding Global Environmental Change: The Contributions of Risk Analysis and Management," convened at Clark University's Center for Technology, Environment, and Development (CENTED) 11–13 October 1989. Under the collective sponsorship of the university's Earth Transformed (ET) Program, the Human Dimensions of Global Change Programme (HDGCP), the Society for Risk Analysis (SRA), and the United Nations University (UNU), the workshop brought together some two dozen prominent scholars from diverse disciplines and a dozen countries.

Workshop participants grappled with teasing out the potential lessons that the risk community, long accustomed as it was to dealing with complex problems beset by large uncertainties, might bring to studies of the human dimensions of global environmental change. Rather remarkably, they managed to prune an overwhelming list of worthy topics to focus on several key initiatives that required immediate attention and to which they agreed to commit their personal efforts. The workshop generated a series of recommendations for future research, which UNU subsequently decided to support. This book is the culmination of that work.

For Demetri and Kyra

Acknowledgements

The editors owe a great deal to participants at an international workshop, “Understanding Global Environmental Change: The Contributions of Risk Analysis and Risk Management,” convened at Clark University in 1989. This sterling assemblage of colleagues – Harold Brookfield, William Clark, Rob Coppock, Exequiel Ezcurra, Silvio O. Funtowicz, Gordon T. Goodman, Saburo Ikeda, N. S. Jodha, Robert W. Kates, Ashok Khosla, Diana Liverman, Giandomenico Majone, Walther Manshard, James K. Mitchell, Elmer Offenbacher, Timothy O’Riordan, Cheri Ragaz, Steve Rayner, Kenneth Richards, Galina Sdasyuk, Kirk R. Smith, Michael Tiller, Peter Timmerman, and B. L. Turner, II – first stimulated the undertaking of this volume. Many of them ended up as authors or coauthors of individual chapters – but even those who did not influenced the final product immensely.

At a crucial juncture, Roland Fuchs, then Vice-Rector of the United Nations University (UNU), encouraged the preparation of *Global Environmental Risk* and facilitated that institution’s provision of needed support. Juha Uitto, Senior Programme Officer at UNU, carried through on this original commitment. More recently, Dr Manfred Boemeke, Director of UNU Press, and Managing Editor Janet Boileau have guided the volume through the final stages of production. We also salute Heather Russell, whose superb copy-editing is evident in every chapter.

At our home institution, many people have contributed generously with their time and talents. Anne Gibson, director of Clark University’s

cartographic laboratory created the handsome maps and other graphics displayed throughout this volume. Miriam Berberian, Betty Jean Perkins, and Octavia Taylor, have put up with our absences “to work on the book” and dispensed generous doses of patience, support, and humour at every stage. And our indispensable accomplice, Lu Ann Pacenka, has come through yet again and transformed another of our tangled webs into a real book.

In this book we have sought to wed two important fields – risk analysis and the human dimensions of global environmental change. The relatively mature field of risk analysis, owing to considerable experience in assessing and managing complex problems with large uncertainties, is well positioned to contribute to the analysis and solution of global environmental problems. We encourage integrated, holistic approaches to addressing the myriad threats to the global environment. In so doing, we invite others to join us in taking up the work of two visionary pioneers, who have boldly charted potential routes for confronting global environmental risks – Gordon T. Goodman and Robert W. Kates.

Jeanne X. Kasperson
Roger E. Kasperson
Worcester, Massachusetts, USA
Stockholm, Sweden

Contents

List of figures and tables	xi
Acknowledgements	xvii

Introduction

1	Introduction: Global environmental risk and society <i>Roger E. Kasperson, Jeanne X. Kasperson, and Kirstin Dow, with contributions from Exequiel Ezcurra, Diana M. Liverman, James K. Mitchell, Samuel J. Ratick, Timothy O’Riordan, and Peter Timmerman</i>	1
---	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	---

Part One	CHARACTERIZING GLOBAL ENVIRONMENTAL RISKS	49
-----------------	--------------------------------------------------	----

	Editors’ Introduction	51
--	------------------------------	----

2	International comparisons of environmental hazards <i>Vicki Norberg-Bohm, William C. Clark, Bhavik Bakshi, Jo Anne Berkenkamp, Sherry A. Bishko, Mark D. Koehler, Jennifer A. Marrs, Chris P. Nielsen, and Ambuj Sagar</i>	55
---	-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------	----

3	The risk transition and developing countries <i>Kirk R. Smith</i>	148
4	Global risk, uncertainty, and ignorance <i>Silvio O. Funtowicz and Jerome R. Ravetz</i>	173
Part Two	VULNERABILITY	195
	Editors' Introduction	197
5	Vulnerability to global environmental change <i>Diana M. Liverman</i>	201
6	Vulnerability to global environmental change in natural ecosystems and rural areas: A question of latitude? <i>Exequiel Ezcurra, Alfonso Valiente-Banuet, Oscar Flores-Villela, and Ella Vázquez-Domínguez</i>	217
7	Vulnerability, equity, and global environmental change <i>Roger E. Kasperson, Jeanne X. Kasperson, and Kirstin Dow</i>	247
Part Three	HIGH-RISK REGIONS	273
	Editors' Introduction	275
8	Trajectories of threat: Assessing environmental criticality in nine regions <i>Jeanne X. Kasperson, Roger E. Kasperson, and B. L. Turner, II</i>	280
9	Global change and environmental risks in mountain ecosystems <i>N. S. Jodha</i>	306
10	Vulnerability to drought and climate change in Mexico <i>Diana M. Liverman</i>	343
11	Sea-level rise and the Bangladesh and Nile deltas <i>James M. Broadus[†]</i>	353

12	Sea-level rise and the North Sea <i>Timothy O’Riordan</i>	373
13	Sea-level rise and the Sea of Japan <i>Saburo Ikeda and Masaaki Kataoka</i>	397
Part Four	GLOBAL ENVIRONMENTAL FUTURES	423
	Editors’ Introduction	425
14	Risk and imagining alternative futures <i>Timothy O’Riordan and Peter Timmerman</i>	429
15	Exploring a sustainable future for Canada <i>John B. Robinson</i>	451
16	Social visions of future sustainable societies <i>Patricia Benjamin, Jeanne X. Kasperson, Roger E. Kasperson, Jacque L. Emel, and Dianne E. Rocheleau</i>	467
	References	506
	Contributors	563
	Index	566

Figures and tables

Figures

1.1	Space and scale relationships in global environmental change	12
1.2	Societal response to global environmental risk	20
1.3	Simple model of the structure of environmental risk	26
1.4	Framework for the analysis of risk amplification and attenuation	36
2.1	The causal structure of environmental hazards	59
2.2	The causal structure of stratospheric ozone depletion	63
2.3	Relevance of causal structure for hazard management: The example of stratospheric ozone depletion	64
2.4	Causal taxonomy for comparative assessment of environmental hazards	65
2.5	The causal structure of climate change	69
2.6	Hazard rankings by total consequence aggregation for the United States	76
2.7	Comparisons of hazard rankings for the United States: Total current consequences versus total future consequences	78
2.8	Comparisons of hazard rankings for the United States: Total consequences versus pervasiveness	80

2.9	Comparisons of hazard rankings for the United States: Total consequences versus disruption	82
2.10	Comparison of hazards ranked as most severe in terms of total consequences for the Netherlands, United States, India, and Kenya	84
2.11	Comparison of hazards ranked as most severe in terms of total current consequences for the Netherlands, United States, India, and Kenya	86
2.12	Comparison of hazards ranked as most severe in terms of total future consequences for the Netherlands, United States, India, and Kenya	87
2.13	Cross-national comparisons of hazard rankings: Total consequences versus pervasiveness for (a) India, (b) Kenya, (c) the Netherlands, (d) USA	88
3.1	The health transition	151
3.2	National income and health: 1940 versus 1970	153
3.3	Trends in modern and traditional diseases for a cross-section of countries: (a) relative probabilities of death; (b) life-years lost to different risks, and total risks	154
3.4	Historical risk trends in Sweden: (a) deaths from epidemic disease, infectious disease, and cancer, 1870–1970; (b) deaths from accidents, drowning, and motor vehicles, 1870–1970	155
3.5	The risk transition	161
4.1	A diagram of problem-solving strategies	181
4.2	Applied science as a problem-solving strategy	182
4.3	Professional consultancy as a problem-solving strategy	185
4.4	Post-normal science as a problem-solving strategy	188
6.1	Mean latitudinal extents of (a) North American trees native to various latitudes, (b) North American marine molluscs with hard body-parts, and (c) North American herpetofauna (amphibians and reptiles)	224
6.2	Micro-endemism in North American mammals.	225
6.3	(a) Geographic distribution of species-richness of columnar cacti in Mexico. (b) Geographic distribution of the residuals of species diversity once the best-fit climatic model has been adjusted to the data	228
6.4	Geographic distribution of endemic amphibians and reptiles in Mexico	230
6.5	Tide level (a) and distribution of mangrove (<i>Avicennia</i> spp.) forests (b)	235
6.6	Geographic distribution of cloud forests in Mexico	237

7.1	Highly simplified model of the structure of environmental risk	252
7.2	Types of ecosystem fragility	255
7.3	Schematic diagram of vulnerability to food crises	257
7.4	Framework for equity analysis of global environmental change	265
8.1	Map of case studies of environmentally threatened regions	286
8.2	Regional changes in environment, human well-being, and sustainability of uses	290
8.3	Regional trajectories and emerging criticality	291
8.4	Regional trajectories of environmental recoverability and the costs of mitigation and/or substitution	292
11.1	Two deltas: (a) the Nile delta and (b) Bangladesh	356
12.1	Frequency distribution curves for the UK East Coast study area. The curves illustrate the shortening of the 1-in-250-year return period, corresponding to the sea-level rise at 2030	377
12.2	Outcrop areas of major aquifers in England and Wales, showing coastlines that are in hydraulic contact with the sea	379
12.3	Present flood-risk areas in England and Wales, as defined by Water Authority Section 24 (5) Surveys between 1975 and 1981	382
12.4	Channel currents of the North Sea	383
12.5	Low-lying areas of the Netherlands	390
13.1	Geographic location of regions surrounding the Sea of Japan	398
13.2	Conceptual model of the economic–ecological system in coastal regions	401
13.3	Sea currents in and around the Sea of Japan	405
13.4	Industrial cities in Japanese coastal zones mandated to establish pollution-control plans	407
13.5	Acidity in rainfall over the Japanese coast	408
13.6	Possible climate changes in the Japanese islands	410
13.7	Schematic illustration of water circulation in the Sea of Japan	413
13.8	Long-range transport of SO₂ in water, with estimated sources of SO₂ emission	414
13.9	Complementary resource relations in the Sea of Japan region	417
14.1	Tilden's model applied to a research project	446
14.2	Tilden's model extended as the basis of the current interpretive experiment	447

15.1	Sustainable Society Project: Conceptual framework	459
15.2	Sequence of Working Papers for the Sustainable Society Project	462

Tables

1.1	Types of global environmental change	3
1.2	Societal monitoring and alerting mechanisms	32
1.3	Increasing resilience and adaptability to surprise	34
2.1	Descriptors	66
2.2	Environmental hazards	70
2.3	Aggregation schemes used in interpreting data	75
2.1A	Scoring <i>Spatial Extent</i> of a single event	96
2.2A	Scoring <i>Disturbance to the Environment</i>	98
2.3A	Scoring annual rate of <i>Change in Perturbation</i>	99
2.4A	Scoring <i>Anthropogenic Flux</i>	100
2.5A	Scoring annual rate of <i>Change in Anthropogenic Flux</i>	101
2.6A	Scoring <i>Persistence</i>	102
2.7A	Scoring <i>Population Exposed</i>	103
2.8A	Scoring <i>Land Exposed</i>	104
2.9A	Scoring <i>Delay</i> between human actions and first evidence of consequences	105
2.10A	Scoring <i>Human Mortality (Current Annual)</i>	105
2.11A	Scoring "<i>Natural</i>" <i>Ecosystem Impacts (Current Annual)</i>	106
2.12A	Scoring <i>Material and Productivity Losses (Current Annual)</i>	107
2.13A	Scoring <i>Recovery Period</i>	107
2.14A	Scoring <i>Future Human Health Consequences</i>	108
2.15A	Scoring sources of <i>Transnational</i> consequences	110
2.16A	India: Hazard taxonomy scores	132
2.17A	Kenya: Hazard taxonomy scores	134
2.18A	The Netherlands: Hazard taxonomy scores	136
2.19A	United States: Hazard taxonomy scores	138
2.20A	Correlation matrix for descriptors	142
2.21A	Highly correlated descriptors	143
2.22A	Results of PCA for descriptors' component correlations (factor loadings)	144
2.23A	Result of varimax rotation of first six principal components	145
2.24A	Descriptors forming each rotated PC	146

5.1	Some factors determining the vulnerability of agricultural producers to climate change	209
6.1	Classification of the different hierarchical levels of biological diversity	221
6.2	Vavilov centres of crop diversity, with selected species	242
6.3	Regions of diversity	244
7.1	Factors contributing to vulnerability to global environmental change	253
7.2	Countries with per capita annual renewable water supplies below 1.700 cubic metres per person per year (as of the mid-1990s)	262
7.3	Estimates of global morbidity and mortality of water-related disease (early 1990s)	263
8.1	A classification of regional environmental situations	282
8.2	Characteristics of the study regions	288
9.1	Indicators of the “skewed perspectives” on global environmental change	307
9.2	Mountain specificities and their environmental stability/risk imperatives	314
9.3	Mountain specificities, human adaptations, and implications for environmental stability/risk	315
9.4	Interaction between resource-intensification factors and mountain specificities affecting environmental stability/risk in mountains	316
9.5	People’s traditional adaptation strategies in response to mountain specificities	322
9.6	Negative changes as indicators of emerging environmental risks in mountain areas	326
9.7	Potential accentuation of cumulative environmental change under the impacts of systemic environmental changes	337
9.8	Environmental change and socio-economic impacts/vulnerabilities in mountain areas	339
12.1	Sea-level rise predictions for the southern North Sea	376
12.2	Examples of erosion scenarios for a cliff currently being eroded at 1 metre/year on the Norfolk coast	384
12.3	Total cost of raising coastal walls (dykes) over a 100-year period	393
12.4	Total cost of protecting Lakes Ijssel and Marken over 100-year period	394
12.5	Policy alternatives for the defence of the dune coast	394
12.6	Policy aims and technical realization for the four types of coast	395

13.1	Systems-management issues of environmental risks in constructing economic–ecological models	403
13.2	Estimated anthropogenic sulphur dioxide emissions in East Asia	415
15.1	Principles of sustainability	464
16.1	Attributes of social visions	479
16.2	Comparison of social attributes of first-generation global models	482